HEAD-MOUNTED ELECTRONIC DEVICE WITH SELF-MIXING SENSORS

[0001] This application claims the benefit of provisional patent application No. 63/028,458, filed May 21, 2020, which is hereby incorporated by reference herein in its entirety.

FIELD

[0002] This relates generally to electronic devices, and, more particularly, to electronic devices such as head-mounted devices having optical components.

BACKGROUND

[0003] Electronic devices such as head-mounted devices may have displays for displaying images and may have other optical components.

SUMMARY

[0004] A head-mounted device may have a head-mounted housing. Optical components may be supported by the head-mounted housing. The optical components may include cameras such as front-facing cameras and/or optical modules that have displays for displaying images to eye boxes.

[0005] Optical self-mixing sensors may be provided in the head-mounted device to detect changes in position between portions of the head-mounted device. These changes may include changes in the positions between optical module components such as lenses and displays. These changes may also involve movement of optical components such as cameras.

[0006] In response to detecting a change in optical component position using the optical self-mixing sensors (e.g., a change indicating that a component or other structure has moved from its desired position), actuators in the device may be adjusted to move the optical components or other action may be taken to compensate for the change.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a top view of an illustrative head-mounted device in accordance with an embodiment.

[0008] FIG. **2** is a rear view of an illustrative head-mounted device in accordance with an embodiment.

[0009] FIG. **3** is a schematic diagram of an illustrative head-mounted device in accordance with an embodiment.

[0010] FIG. **4** is a diagram of an illustrative self-mixing sensor in accordance with an embodiment.

[0011] FIG. **5** contains graphs illustrating operation of the self-mixing sensor of FIG. **4** in accordance with an embodiment.

[0012] FIG. **6** is a cross-sectional side view of an illustrative display system in accordance with an embodiment.

[0013] FIG. **7** is a cross-sectional side view of an illustrative camera system in accordance with an embodiment.

[0014] FIGS. **8**, **9**, **10**, **11**, **12**, and **13** are cross-sectional side views of illustrative optical systems with self-mixing sensors in accordance with embodiments.

[0015] FIG. **14** is a flow chart of illustrative operations associated with operating an electronic device with a self-mixing sensor in accordance with an embodiment.

DETAILED DESCRIPTION

[0016] An electronic device such as a head-mounted device may have optical components. The optical components may include optical modules that are used to provide images to a user's eyes. The head-mounted device may also have other optical components such as cameras. Components in a head-mounted have the potential to experience misalignment if the device is subjected to stress during a drop event or other high stress event. To ensure that the device operates satisfactory, optical self-mixing sensors may be used to accurately measure the positions of components in the head-mounted device. Actuators may then move the optical components to compensate for any detected changes in position and/or other compensating action may be taken.

[0017] A top view of an illustrative head-mounted device is shown in FIG. **1**. As shown in FIG. **1**, head-mounted devices such as electronic device **10** may have head-mounted support structures such as housing **12**. Housing **12** may include portions (e.g., head-mounted support structures **12**T) to allow device **10** to be worn on a user's head. Support structures **12**T may be formed from fabric, polymer, metal, and/or other material. Support structures **12**T may form a strap or other head-mounted support structures to help support device **10** on a user's head. A main support structure (e.g., a head-mounted housing such as main housing portion **12**M) of housing **12** may support electronic components such as displays **14**.

[0018] Main housing portion **12**M may include housing structures formed from metal, polymer, glass, ceramic, and/or other material. For example, housing portion **12**M may have housing walls on front face F and housing walls on adjacent top, bottom, left, and right side faces that are formed from rigid polymer or other rigid support structures and these rigid walls may optionally be covered with electrical components, fabric, leather, or other soft materials, etc. Housing portion **12**M may also have internal support structures such as a frame and/or structures that perform multiple functions such as controlling airflow and dissipating heat while providing structural support. The walls of housing portion **12**M may enclose internal components **38** in interior region **34** of device **10** and may separate interior region **34** from the environment surrounding device **10** (exterior region **36**). Internal components **38** may include integrated circuits, actuators, batteries, sensors, and/or other circuits and structures for device **10**. Housing **12** may be configured to be worn on a head of a user and may form glasses, a hat, a helmet, goggles, and/or other head-mounted device. Configurations in which housing **12** forms goggles may sometimes be described herein as an example.

[0019] Front face F of housing **12** may face outwardly away from a user's head and face. Opposing rear face R of housing **12** may face the user. Portions of housing **12** (e.g., portions of main housing **12**M) on rear face R may form a cover such as cover **12**C. The presence of cover **12**C on rear face R may help hide internal housing structures, internal components **38**, and other structures in interior region **34** from view by a user.

[0020] Device **10** may have one or more cameras such as cameras **46** of FIG. **1**. For example, forward-facing (front-facing) cameras may allow device **10** to monitor movement of the device **10** relative to the environment surrounding device **10** (e.g., the cameras may be used in forming a visual odometry system or part of a visual inertial odometry system). Forward-facing cameras may also be used to cap-